

LEVEL

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SUSQUEHANNA RIVER BASIN
STERLING BROOK, SUSQUEHANNA COUNTY
PENNSYLVANIA

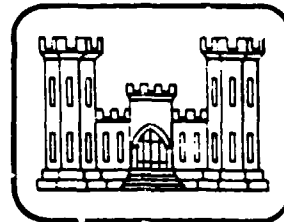
HORTON LAKE DAM

NDI No. PA 00070
PennDER No. 58-124
Dam Owner: Harry Horton



PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

DAEW 31-81-C-0011



prepared for

DEPARTMENT OF THE ARMY
Baltimore District, Corps of Engineers
Baltimore, Maryland 21203

prepared by

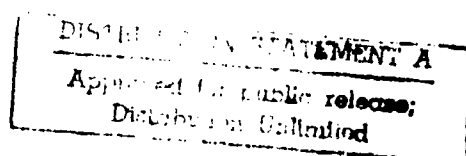
MICHAEL BAKER, JR., INC.

Consulting Engineers
4301 Dutch Ridge Road
Beaver, Pennsylvania 15009

June 1981

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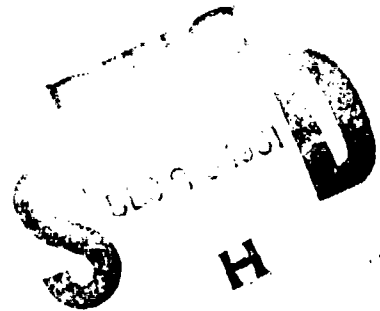
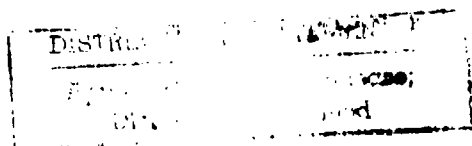
PREFACE

This report is prepared under guidance contained in the "Recommended Guidelines for Safety Inspection of Dams," for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigations and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I Investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I Inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The spillway design flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.



PHASE I REPORT
NATIONAL DAM INSPECTION PROGRAM

Horton Lake Dam, Susquehanna County, Pennsylvania
NDI No. PA 00070, PennDER No. 58-124
Sterling Brook
Inspected 30 October 1980

ASSESSMENT OF
GENERAL CONDITIONS

Horton Lake Dam is owned by Harry Horton and is classified as a "Significant" hazard - "Small" size dam. The dam was found to be in good overall condition at the time of inspection.

Hydraulic/hydrologic evaluations, performed in accordance with procedures established by the Baltimore District, Corps of Engineers, for Phase I Inspection Reports, revealed that the spillway capacity is less than the peak inflow to the reservoir during the 100-year flood. A spillway design flood (SDF) in the range of the 100-year flood to the 1/2 Probable Maximum Flood (1/2 PMF) is required for Horton Lake Dam. Because the dam is on the low end of the "Small" size category in terms of height and storage capacity, the 100-year flood was chosen as the SDF. The spillway is therefore considered "Inadequate." It is recommended that the owner develop remedial measures to ensure that the dam is not overtopped by the 100-year flood.

Several items of remedial work should be immediately initiated by the owner. These include:

- 1) Develop remedial measures to ensure that the dam is not overtopped by the 100-year flood.
- 2) Fill the low area to the left of the spillway structure.
- 3) Check the operability of the outlet works valve and restore to a good operable condition.
- 4) Cut the trees and brush from the dam and for 10 feet below the toe of the dam.
- 5) Remove the trees and stumps from the spillway discharge apron.

In addition, the following operational measures are recommended to be undertaken by the owner:

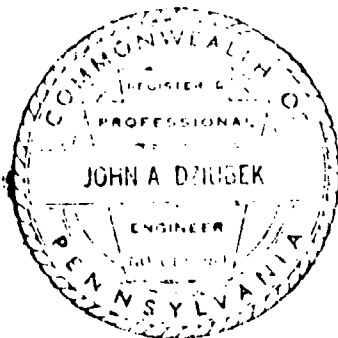
HORTON LAKE DAM

- 1) Develop a detailed emergency operation and warning system.
- 2) During periods of unusually heavy rainfall, provide around-the-clock surveillance of the dam.
- 3) When warning of a storm of major proportions is given by the National Weather Service, activate the emergency operation and warning system.

It is further recommended that formal inspection, maintenance, and operational procedures and records be developed and implemented. These should be included in a formal maintenance and operations manual for the dam.

Submitted by:

MICHAEL BAKER, JR., INC.



John A. Dziubek
John A. Dziubek, P.E.
Engineering Manager-Geotechnical

Date: June 26, 1981

Approved by:

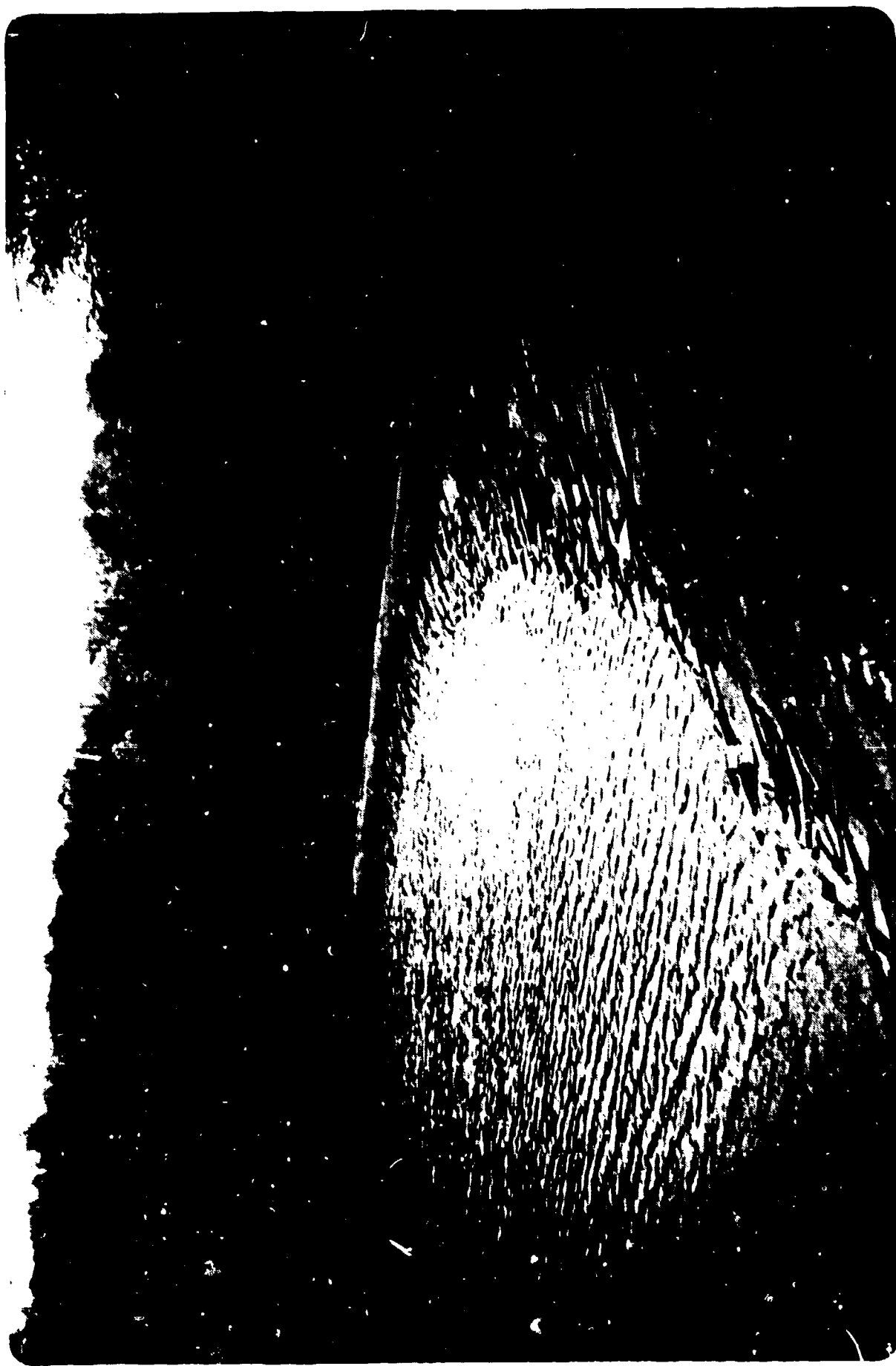
DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS

James W. Peck
JAMES W. PECK
Colonel, Corps of Engineers
Commander and District Engineer

Date: 7 July 81

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HORTON LAKE DAM



**Overall View of Dam from Right Abutment - Spillway Located
at Left Abutment**

TABLE OF CONTENTS

	<u>Page</u>
Section 1 - Project Information	1
Section 2 - Engineering Data	5
Section 3 - Visual Inspection	7
Section 4 - Operational Procedures	8
Section 5 - Hydraulic/Hydrologic	9
Section 6 - Structural Stability	10
Section 7 - Assessment, Recommendations/Remedial Measures	11

APPENDICES

Appendix A - Visual Inspection Check List, Field Sketch, Top of Dam Profile, and Typical Cross-Section
Appendix B - Engineering Data Check List
Appendix C - Photograph Location Plan and Photographs
Appendix D - Hydrologic and Hydraulic Computations
Appendix E - Plates
Appendix F - Regional Geology

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
HORTON LAKE DAM
NDI No. PA 00070, PennDER No. 58-124

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

- a. Authority - The Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of inspection of dams throughout the United States.
- b. Purpose of Inspection - The purpose of the inspection is to determine if the dam constitutes a hazard to human life or property.

1.2 DESCRIPTION OF PROJECT

- a. Description of Dam and Appurtenances - Horton Lake Dam is an earthfill embankment 358 feet long and 9.5 feet high. The embankment has a crest width of 9 feet and side slopes of 2H:1V (Horizontal to Vertical) upstream and 2.5H:1V downstream. The upstream face of the embankment is protected with riprap. A cut-off trench extends the entire length of the embankment. It has a bottom width of 10 foot with 0.25H:1V side slopes. It was designed for a depth of 4 feet below the toe of the upstream slope.

The spillway, located at the left abutment, consists of a concrete broad-crested weir which is 39.5 feet long perpendicular to the direction of flow. Concrete spillway training walls extend 1.5 feet above the crest of the weir.

The outlet works for the dam consist of an 18 inch diameter corrugated metal pipe encased in 6 inches of concrete with two concrete anti-seep collars (6.5 feet by 6.5 feet). A sliding gate valve located on the upstream slope controls the submerged intake of the outlet works.

- b. Location - Horton Lake Dam is located on Sterling Brook in Lenox Township, Susquehanna County, Pennsylvania. The dam is approximately 1.33 miles southwest of Harding Corners in Hartford Township. The coordinates of the dam are N 41° 43.5' and W 75° 41.6'. The dam can be found on the USGS 7.5 minute topographic quadrangle, Lenoxville, Pennsylvania.

- c. Size Classification - The height of the dam is 9.5 feet. Storage at the top of the dam [Elevation 1259.5 feet Mean Sea Level (ft. M.S.L.)] is 345 acre-feet. The dam is therefore in the "Small" size category.
- d. Hazard Classification - Loss of life is considered unlikely; however, if the dam should fail, damage to Route 106 located 500 feet downstream would occur. Minor economic damage to the township road located 3000 feet downstream from the dam may also occur. Therefore, the dam is considered to be in the "Significant" hazard category.
- e. Ownership - The dam is owned by Harry Horton, Box 36, Clifford, Pennsylvania 18413.
- f. Purpose of Dam - The impoundment created by the dam is used for recreation and fishing. *Go to 8*
- g. Design and Construction History - Horton Lake Dam was designed by L. F. Burlein, P.E., of Honesdale, Pennsylvania, in 1956. Construction of the dam began during the summer of 1956 and was completed 17 October 1956. The contractor was Homer Ross of Jackson, Pennsylvania.
- h. Normal Operational Procedures - The reservoir is typically maintained at the spillway crest, Elevation 1258.00 ft. M.S.L.

1.3 PERTINENT DATA

a. <u>Drainage Area (square miles)</u> -	0.58
b. <u>Discharge at Dam Site (c.f.s.)</u> -	
Maximum Flood -	Unknown
Spillway Capacity at Maximum Pool (El. 1259.5 ft. M.S.L.) -	190
c. <u>Elevation* (feet above Mean Sea Level [ft. M.S.L.])</u> -	
Design Top of Dam -	Unknown
Minimum Top of Dam -	1259.5
Maximum Design Pool -	Unknown
Spillway Crest -	1258.0
Streambed at Toe of Dam -	1250.0
Maximum Tailwater of Record -	Unknown

*All elevations are referenced to the spillway crest of the dam, El. 1258.0 ft. M.S.L., estimated from the USGS 7.5 minute topographic quadrangle, Lenoxville, Pennsylvania.

d. Reservoir (feet) -

Length of Maximum Pool
(El. 1259.5 ft. M.S.L.) - 2550

Length of Normal Pool
(El. 1258.0 ft. M.S.L.) - 2300

e. Storage (acre-feet) -

Top of Dam (El. 1259.5 ft. M.S.L.) - 345
Normal Pool (El. 1258.0 ft. M.S.L.) - 280

f. Reservoir Surface (acres) -

Top of Dam (El. 1259.5 ft. M.S.L.) - 58
Normal Pool (El. 1258.0 ft. M.S.L.) - 46

g. Dam -

Type - Earthfill embankment
Total Length Including Spillway (feet) - 358
Height (feet) - Design - 9.5
Field - 9.5
Top Width (feet) - Design - 12
Field - 9
Side Slopes - Upstream - Design 2H:1V
Field - 2H:1V
Downstream - Design - 2H:1V
Field - 2.5H:1V
Zoning - None
Impervious Core - None
Cut-off - Cut-off trench extends the entire length of the embankment. It has a bottom width of 10 ft. with 0.25H:1V side slopes. It was designed for a depth of 4 ft. below the toe of the upstream slope. It is backfilled with impervious soil.

Drains - None

h. Diversion and Regulating Tunnel - None

i. Spillway -

Type - Concrete broad-crested weir
Location - Left abutment
Width of Crest Parallel to Flow
(feet) - 4.7
Length of Crest Perpendicular to
Flow (feet) - 39.5
Crest Elevation (ft. M.S.L.) - 1258.0
Gates - None
Downstream Channel - Swampy with woods on both sides of swamp.

- j. Outlet Works - The outlet works consist of an 18 in. corrugated metal pipe encased in 6 inches of concrete with two 6.5 ft. by 6.5 ft. anti-seep collars. A sliding gate valve, located 6 ft. upstream from the embankment crest on the upstream slope, controls the submerged intake of the outlet works.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

Information reviewed for preparation of this report consisted of the Pennsylvania Department of Environmental Resources' (PennDER) File No. 58-124. This included:

- 1) The permit application to the Commonwealth of Pennsylvania, Water and Power Resources Board, from Harry Horton, owner of the dam (dated 1 February 1956).
- 2) Cross sections of the reservoir and the earth embankment as proposed by Mr. L. F. Burlein, Registered Engineer.
- 3) The permit issued by the Water and Power Resources Board, allowing construction of the dam (dated 14 March 1956).
- 4) Post construction inspection reports, conducted 2 May 1958, and 15 November 1958, by PennDER, Division of Dams and Encroachments.
- 5) Various correspondence between Harry Horton and the Division of Dams and Encroachments.
- 6) The latest inspection report, dated 10 August 1965, filed by PennDER, Division of Dams and Encroachments. Brush growing on the embankment and wasteway channel, and stumps and debris along the spillway crest were two areas indicated in need of maintenance. Further correspondence indicated this problem was corrected.

2.2 CONSTRUCTION

Construction of the dam was started in the summer of 1956 and completed by 17 October 1956. The contractor was Homer Ross of Jackson, Pennsylvania.

2.3 OPERATION

No formal records are available for operation of the dam and reservoir. The spillway is uncontrolled and the reservoir is typically at the spillway crest level.

2.4 EVALUATION

- a. Availability - The information reviewed is readily available from PennDER File No. 58-124.
- b. Adequacy - The information available combined with the visual inspection measurements and observations is adequate for a Phase I Inspection of this dam.
- c. Validity - Except for differences between the constructed facility and the configurations shown on the plates in Appendix E, there is no reason at the present time to doubt the validity of the available engineering data. Significant variations are discussed in the various sections of this report.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General - The dam was found to be in good overall condition at the time of inspection on 30 October 1930. No unusual weather conditions were experienced during the inspection. Noteworthy deficiencies observed during the visual inspection are described briefly in the following paragraphs. The complete visual inspection check list, field sketch, top of dam profile, and typical cross-section are presented in Appendix A.

b. Embankment - A low area of the crest is located immediately to the left of the spillway structure. The downstream slope is covered with a thick growth of trees and brush.

c. Appurtenant Structures - Some logs and stumps have been deposited on the spillway discharge apron. Rocks were observed wedged between the valve stem and casing pipe for the outlet works. The owner indicated this valve has never been operated.

Differences between the design drawings and field conditions include the following items: 1) less freeboard than indicated, 2) broad-crested weir instead of sharp-crested weir, and 3) access to the intake structure is different from that indicated on the design plans included in Appendix E.

d. Reservoir Area - The reservoir slopes are moderate and no sign of instability was observed. A small amount of sedimentation has occurred at the upper end of the reservoir.

e. Downstream Channel - The channel passes through a swampy area with some minor ponded areas before passing under Route 106, 500 feet downstream of the dam. A township road is located 3000 feet downstream of the dam. Economic damage is likely to result to both roads in the event of failure of the dam.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

There are no formal operating procedures for this dam. It is recommended that formal emergency procedures be adopted, prominently displayed and furnished to all operating personnel.

4.2 MAINTENANCE OF DAM

There are no formal records of maintenance or formal procedures for evaluating the necessity of maintenance for the structure. It is recommended that formal inspection procedures be developed.

4.3 MAINTENANCE OF OPERATING FACILITIES

A steel plate (26 in. by 36 in. by 3/4 in.) operated by a stem and hand wheel from the top of the embankment acts as a gate valve for the emergency outlet works. There are no operation or maintenance records for this gate valve. It is recommended that a formal operation and preventive maintenance schedule be developed and implemented.

4.4 DESCRIPTION OF ANY WARNING SYSTEM

There is no warning system in the event of dam failure. It is recommended that an emergency warning system be developed.

4.5 EVALUATION OF OPERATIONAL ADEQUACY

The current operational features are adequate for the purpose they serve. However, it is recommended that a formal maintenance and operations manual be prepared for the dam.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

- a. Design Data - No hydrologic or hydraulic design calculations are available for Horton Lake Dam.
- b. Experience Data - No information concerning the effects of significant floods on the dam is available.
- c. Visual Observations - During the visual inspection, no problems were observed which would indicate that the dam and appurtenant facilities could not perform satisfactorily during a flood event.
- d. Overtopping Potential - Horton Lake Dam is a "Small" size - "Significant" hazard dam requiring evaluation for a spillway design flood (SDF) in the range of the 100-year flood to the 1/2 Probable Maximum Flood (1/2 PMF). Because the dam is on the low end of the "Small" size category in terms of height and storage capacity, the 100-year flood was chosen as the SDF.

Using material from "The Hydrologic Study - Tropical Storm Agnes" prepared by the Corps of Engineers in New York City, the peak inflow to the impoundment for the 100-year flood was calculated to be 740 c.f.s. The peak inflow to the impoundment from the 100-year flood was also calculated to be 376 c.f.s. using material from "Water Resources Bulletin, Bulletin No. 13, Floods In Pennsylvania", prepared by the Department of Environmental Resources, Commonwealth of Pennsylvania. Averaging these two methods produced a peak inflow of 558 c.f.s. which was used in this analysis.

The spillway capacity at the minimum top of the dam is 192.3 c.f.s. which is approximately 35.4 percent of the peak inflow to the impoundment.

- e. Spillway Adequacy - As outlined in the above analysis, the inflow to the impoundment during the 100-year flood is greater than the spillway capacity; therefore, the spillway is considered "Inadequate".

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

- a. Visual Observations - There were no structural inadequacies noted during the visual inspection that cause concern for the continued structural stability of the dam.
- b. Design and Construction Data - Calculations of slope and structural stability were not available for review. The slopes have had a history of satisfactory performance. In view of the modest height of the dam, a history of satisfactory performance of its moderate slopes, and no signs of distress observed during the visual inspection, no further stability analysis is deemed necessary.
- c. Operating Records - Nothing in the procedures described by the owner's representative indicates concern relative to the structural stability of the dam.
- d. Post-Construction Changes - No changes adversely affecting the structural stability of the dam have been performed.
- e. Seismic Stability - The dam is located in Seismic Zone 1 of the "Seismic Zone Map of the Contiguous United States," Figure 1, page D-30, "Recommended Guidelines for Safety Inspection of Dams." This is a zone of minor seismic activity. Therefore, further consideration of the seismic stability is not warranted.

SECTION 7 - ASSESSMENT, RECOMMENDATIONS/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

- a. Safety - Horton Lake Dam was found to be in good overall condition at the time of inspection. Horton Lake Dam is a "Significant" hazard - "Small" size dam requiring a spillway capacity in the range of the 100-year flood to the 1/2 PMF. The 100-year flood was chosen as the SDF because the dam is on the low side of the "Small" size category based on storage capacity and height. As presented in Section 5, the spillway capacity is less than the peak inflow to the impoundment during the 100-year flood. Therefore, the spillway is considered "Inadequate."
- b. Adequacy of Information - The information available and the observations and measurements made during the field inspection are considered sufficient for this Phase I Inspection Report.
- c. Urgency - The owner should initiate the action discussed in paragraph 7.1.d. as soon as practicable.
- d. Necessity for Additional Data/Evaluation - The hydraulic/hydrologic analysis performed in connection with this Phase I Inspection Report has indicated the need for additional spillway capacity.

7.2 RECOMMENDATIONS/REMEDIAL MEASURES

The inspection revealed certain items of remedial work which should be performed by the owner without delay. These include:

- 1) Develop remedial measures to ensure that the dam will not be overtopped by the 100-year flood.
- 2) Fill the low area to the left of the spillway structure.
- 3) Check the operability of the outlet works valve and restore to a good operable condition.
- 4) Cut the trees and brush from the dam and for 10 feet below the toe of the dam.

- 5) Remove the trees and stumps from the spillway discharge apron.

In addition, the following operational measures are recommended to be undertaken by the owner:

- 1) Develop a detailed emergency operation and warning system.
- 2) During periods of unusually heavy rainfall, provide around-the-clock surveillance of the dam.
- 3) When warning of a storm of major proportions is given by the National Weather Service, activate the emergency operation and warning system.

It is further recommended that formal inspection, maintenance, and operational procedures and records be developed and implemented. These should be included in a formal maintenance and operations manual for the dam.

APPENDIX A

VISUAL INSPECTION CHECK LIST, FIELD SKETCH,
TOP OF DAM PROFILE, AND TYPICAL CROSS-SECTION

Check List
Visual Inspection
Phase 1

A-1

Name of Dam Horton Lake Dam County Susquehanna State PA Coordinates Lat. N 41° 43.5'

NDI # PA 00070
PennDER # 58-124

Long. W 75° 41.6'

Date of Inspection 30 October 1980

Weather Overcast

Temperature 40° F.

1256.36

Pool Elevation at Time of Inspection ft. 1256.36 M.S.L.* Tailwater at Time of Inspection ft. 1250.49 M.S.L.

*All elevations referenced to spillway crest, Elevation 1258.0 ft. M.S.L., estimated from USGS 7.5 minute topographic quadrangle, Lenoxville, Pennsylvania.

Inspection Personnel:

Michael Baker, Jr., Inc.:

James G. Uliniski
Wayne D. Lasch
Jeffrey S. Maze

Owner's Representatives:

Mrs. Harry Horton

James G. Uliniski

Recorder

CONCRETE/MASONRY DAMS - Not Applicable

Name of Dam: HORTON LAKE DAM

NDI # PA 00070

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
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LEAKAGE

STRUCTURE TO
ABUTMENT/EMBANKMENT
JUNCTIONS

DRAINS

WATER PASSAGES

FOUNDATION

A-3

CONCRETE, MASONRY DAMS - Not Applicable

Name of Dam: HORTON LAKE DAM

NDI # PA 00070

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
-----------------------	--------------	----------------------------

SURFACE CRACKS CONCRETE SURFACES		
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STRUCTURAL CRACKING		
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VERTICAL AND HORIZONTAL ALIGNMENT		
--------------------------------------	--	--

MONOLITH JOINTS		
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CONSTRUCTION JOINTS		
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EMBANKMENT

Name of Dam HORTON LAKE DAM
 NDI # PA 00070

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
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SURFACE CRACKS	None observed	
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UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None observed	
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SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	None observed	
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EMBANKMENT

Name of Dam HORTON LAKE DAMNDI # PA 00070

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	The area immediately to the left of the spillway is low.	This area should be filled to the top of the spillway training walls and the area reseeded.

RIPRAP FAILURES

No problems observed.

VEGETATION

The downstream slope is covered
with a thick growth of trees
and brush.Cut the trees and brush on
the dam and for 10 ft. below
the toe of the dam.

EMBANKMENT

Name of Dam HORTON LAKE DAM
 NDI # PA 00070

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Good condition	

ANY NOTICEABLE SEEPAGE	None observed
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STAFF GAGE AND RECORDER	None observed
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DRAINS	None observed
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OUTLET WORKS

Name of Dam: HORTON LAKE DAMNDI # PA 00070

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	Not Applicable	
INTAKE STRUCTURE	Submerged at time of inspection.	
OUTLET STRUCTURE	Submerged at time of inspection.	
OUTLET CHANNEL	Outlet works discharge directly into a bait pond.	
EMERGENCY GATE	Gate valve may be inoperable since rocks have been dropped into the casing pipe and lodged between valve stem and casing pipe.	Valve should be checked and restored to an operable condition.

UNGATED SPILLWAY

Name of Dam: HORTON LAKE DAMNDI # PA 00070

VISUAL EXAMINATION OF		OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR		Good condition	

APPROACH CHANNEL

No problems observed.

DISCHARGE CHANNEL

Channel discharges into swampy area. Some logs and stumps have been deposited on the spillway discharge apron.

Remove logs and stumps and continue to keep free of debris in the future.

BRIDGE AND PIERS

None

GATED SPILLWAY - Not Applicable

Name of Dam: HORTON LAKE DAM

NDI # PA 00070

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
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CONCRETE SILL

APPROACH CHANNEL

DISCHARGE CHANNEL

BRIDGE AND PIERS

GATES AND OPERATION
EQUIPMENT

A-10

INSTRUMENTATION

Name of Dam: HORTON LAKE DAM

NDI # PA 00070

<u>VISUAL EXAMINATION</u>	<u>OBSERVATIONS</u>	<u>REMARKS OR RECOMMENDATIONS</u>
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MONUMENTATION/SURVEYS	None observed	
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OBSERVATION WELLS	None observed	
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WEIRS	None observed	
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PIEZOMETERS	None observed	
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OTHER		
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RESERVOIR

Name of Dam: HORTON LAKE DAM

NDI # PA 00070

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	Moderate slopes (5°-15°) and swampy with good ground cover of woods.	
SEDIMENTATION	Small amount of sedimentation in upper reservoir area.	

DOWNSTREAM CHANNEL

Name of Dam: HORTON LAKE DAMNDI # PA 00070

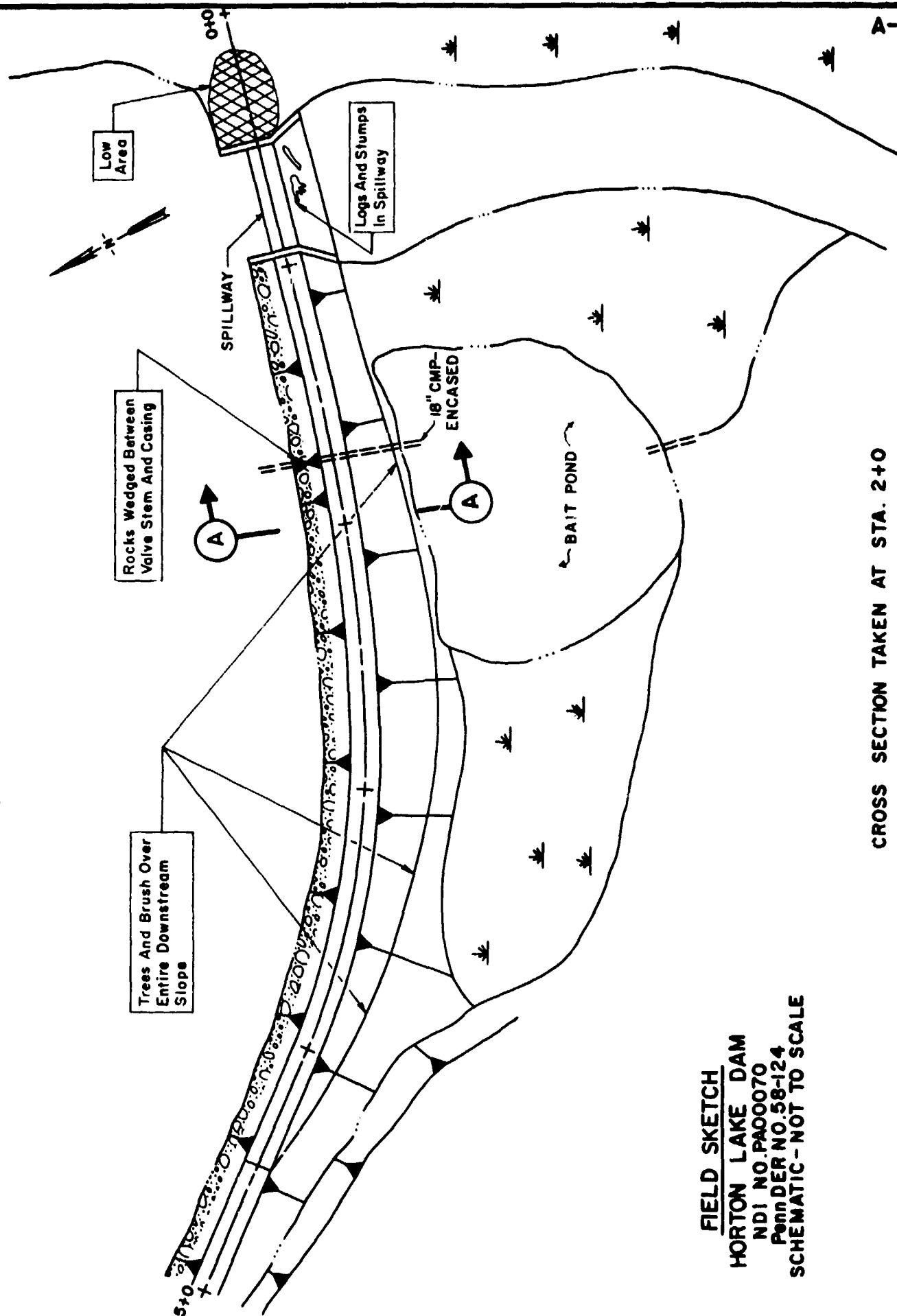
VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	Downstream area is mostly swampy with a stilling basin. A 48 in. concrete pipe conveys water under a road 250 ft. down- stream of dam.	

SLOPES

Mild slopes with good ground cover.

**APPROXIMATE NO.
 OF HOMES AND
 POPULATION**

 Damage may occur to Route 106 if
 the dam should fail. Damage may also
 occur to a township road located down-
 stream of Route 106.



CROSS SECTION TAKEN AT STA. 2+0

FIELD SKETCH
HORTON LAKE DAM
 NDI NO. PA00070
 Penn DER NO 58-124
 SCHEMATIC - NOT TO SCALE

MICHAEL BAKER, JR., INC.

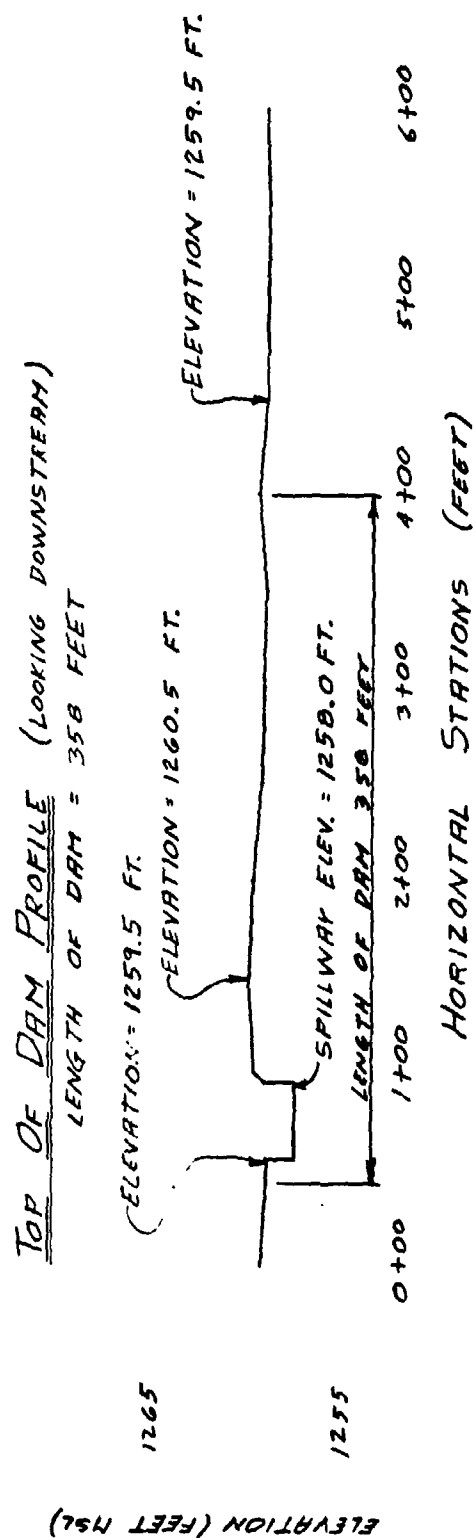
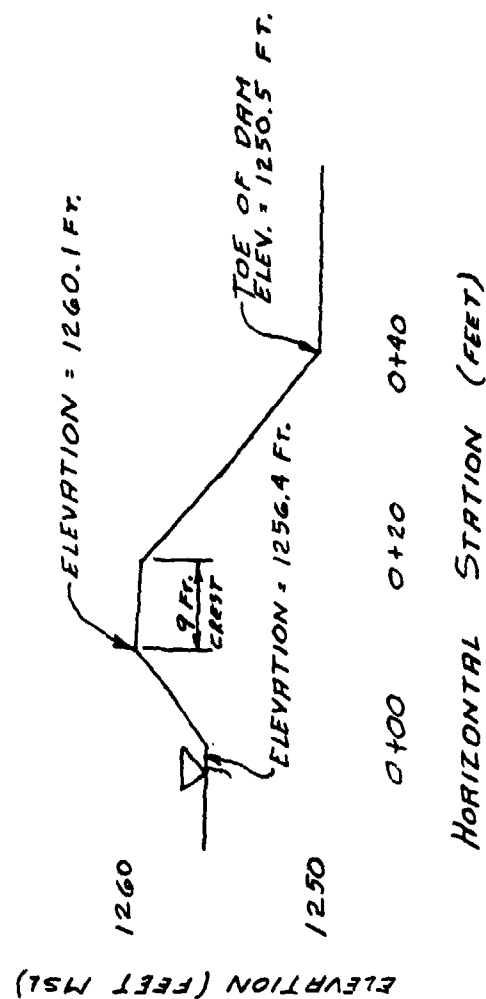
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

HORTON LAKE DAM

TOP OF DAM PROFILE
TYPICAL CROSS-SECTION

DATE OF INSPECTION: 30 October 1980

TYPICAL CROSS SECTION AT STATION 2+00

APPENDIX B
ENGINEERING DATA CHECK LIST

CHECK LIST

B-1

ENGINEERING DATA DESIGN, CONSTRUCTION, OPERATION

Name of Dam: HORTON LAKE DAM

NDI # PA 00070

ITEM

REMARKS

PLAN OF DAM

See Plate 3 of this report.

REGIONAL VICINITY MAP

A USGS 7.5 minute topographic quadrangle, Lenoxville, Pennsylvania, was used to prepare the vicinity map which is enclosed in this report as the Location Plan (Plate 1).

CONSTRUCTION HISTORY

The dam was designed by Mr. L.F. Burlein, Registered Engineer, of Honesdale, Pennsylvania. The contractor was Homer Ross. Construction of the dam was started in the summer of 1956 and completed by 17 October 1956.

TYPICAL SECTIONS OF DAM

See Plate 6 of this report.

HYDROLOGIC/HYDRAULIC DATA

No information available.

OUTLETS - PLAN

- DETAILS

See Plate 5 of this report.

- CONSTRAINTS

None

- DISCHARGE RATINGS

No information available.

RAINFALL/RESERVOIR RECORDS

No records are kept.

Name of Dam: HORTON LAKE DAM

B-2

NDI # PA 00070

ITEM	REMARKS
------	---------

DESIGN REPORTS

None available

GEOLOGY REPORTS

No geology reports are available for the dam. See Appendix F for the Regional Geology.

DESIGN COMPUTATIONS
HYDROLOGY & HYDRAULICS
DAM STABILITY
SEEPAGE STUDIES

None available

MATERIALS INVESTIGATIONS
BORING RECORDS
LABORATORY
FIELD

None available

POST-CONSTRUCTION SURVEYS OF DAM

A post-construction inspection report dated 2 May 1958 (inspection 2 May 1958) is available in the PenndER file.

BORROW SOURCES

No information available.

Name of Dam: HORTON LAKE DAM

NDI # PA 00070

B-3

ITEM	REMARKS
------	---------

MONITORING SYSTEMS

None

MODIFICATIONS

No record of any modifications.

HIGH POOL RECORDS

No information available.

**POST-CONSTRUCTION ENGINEERING
STUDIES AND REPORTS**

The latest inspection report, conducted on 10 August 1965 by PennDER, found the dam to be in need of some maintenance work. Subsequent correspondence indicated the work was completed in October 1965. Other post-construction inspections by PennDER were conducted on 15 November 1958 and 2 May 1958. These reports are available in the PennDER file.

**PRIOR ACCIDENTS OR FAILURE OF DAM
DESCRIPTION
REPORTS**

None reported in the information available.

**MAINTENANCE
OPERATION
RECORDS**

No formal records of maintenance are kept.

Name of Dam: HORTON LAKE DAM

NDI # PA 00070

B-4

ITEM

REMARKS

SPILLWAY PLAN,

SECTIONS,
and
DETAILS

See Plate 4 of this report.

OPERATING EQUIPMENT
PLANS & DETAILS

None

CHECK LIST
HYDROLOGIC AND HYDRAULIC DATA
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: 0.58 sq. mi., primarily forested
land

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 1258.0 ft. M.S.L.
(280 ac.-ft.)

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): 1259.5 ft. M.S.L.
(345 ac.-ft.)

ELEVATION MAXIMUM DESIGN POOL: Unknown

ELEVATION TOP DAM: 1259.5 ft. M.S.L. (minimum top of dam elevation)

SPILLWAY: _____

- a. Crest Elevation 1258.0 ft. M.S.L.
- b. Type Concrete broad-crested weir
- c. Width of Crest Parallel to Flow 4.7 ft.
- d. Length of Crest Perpendicular to Flow 39.5 ft.
- e. Location Spillover At left abutment
- f. Number and Type of Gates None

OUTLET WORKS: _____

- a. Type 18 in. corrugated metal pipe
- b. Location Near the center of the dam
- c. Entrance Inverts El. 1251.5 ft. (computed from design plans)
- d. Exit Inverts Unknown
- e. Emergency Drawdown Facilities Gate valve on upstream slope

HYDROMETEOROLOGICAL GAGES: None

- a. Type _____
- b. Location _____
- c. Records _____

MAXIMUM NON-DAMAGING DISCHARGE Unknown

APPENDIX C

PHOTOGRAPH LOCATION PLAN AND PHOTOGRAPHS

DETAILED PHOTOGRAPH DESCRIPTIONS

Overall View - Overall View of Dam from Right Abutment -
Spillway is Located at Left Abutment

Photograph Location Plan

Photo 1 - View of Upstream Slope of Dam from Left Shoreline

Photo 2 - View along Crest of Dam from Right Abutment

Photo 3 - View of Crest and Downstream Slope from Left
Abutment

Photo 4 - View of Spillway Approach

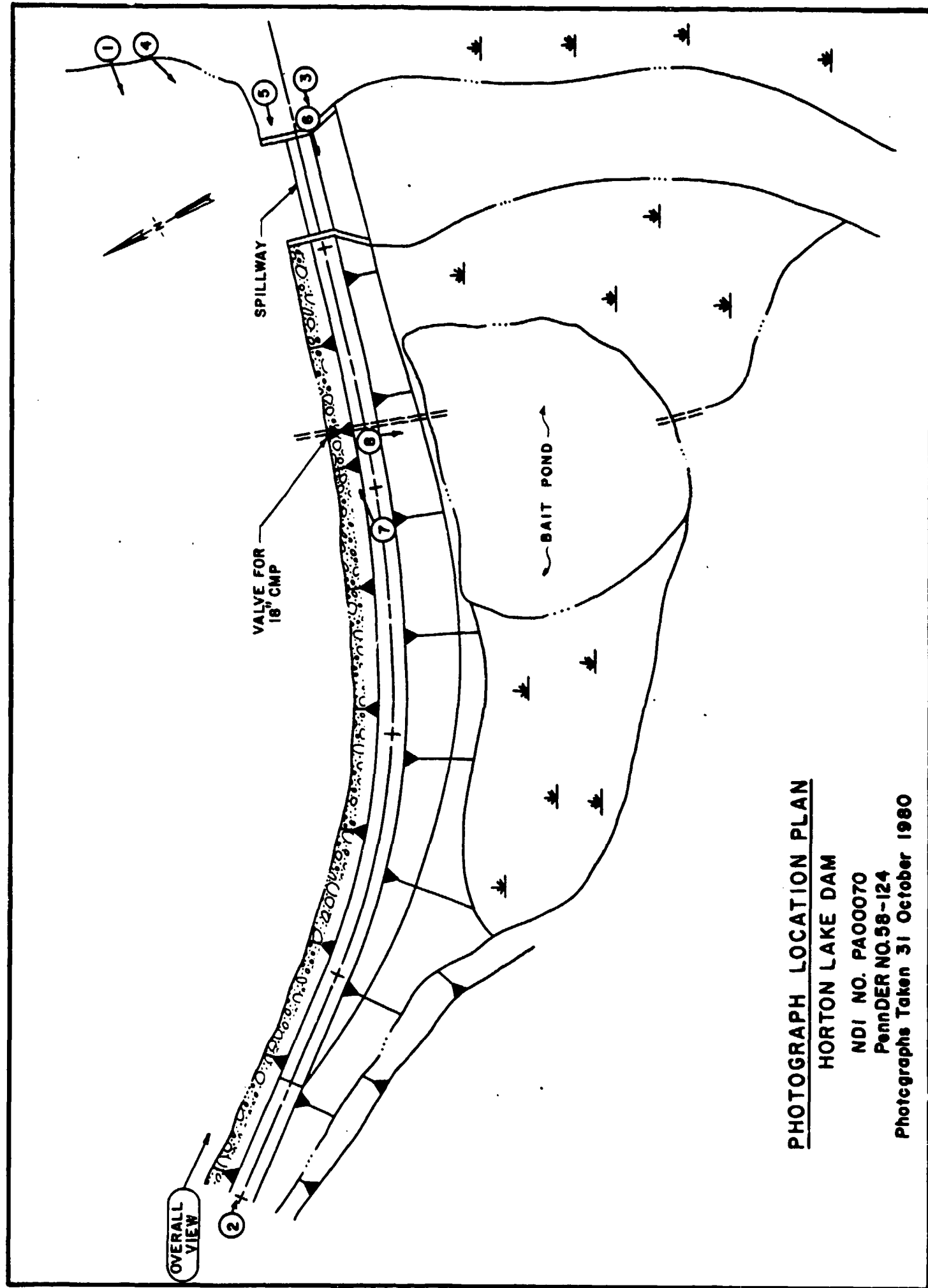
Photo 5 - View Across Crest of Spillway

Photo 6 - View of Spillway Discharge Apron

Photo 7 - View of Riser Casing for Outlet Works Valve
Stem

Photo 8 - View of Bait Pond Downstream of Dam

Note: Photographs were taken on 30 October 1980.



PHOTOGRAPH LOCATION PLAN

HORTON LAKE DAM

NDI NO. PA00070

Pennder NO.58-124

Photographs Taken 31 October 1980

HORTON LAKE DAM



PHOTO 1. View of Upstream Slope of Dam from Left Shoreline



PHOTO 2. View Along Crest of Dam from Right Abutment

HORTON LAKE DAM



PHOTO 3. View of Crest and Downstream Slope from Left Abutment



PHOTO 4. View of Spillway Approach

HORTON LAKE DAM



PHOTO 5. View Across Crest of Spillway



PHOTO 6. View of Spillway Discharge Apron

HORTON LAKE DAM



PHOTO 7. View of Riser Casing for Outlet Works Valve Stem



PHOTO 8. View of Ball Pond Downstream of Dam

APPENDIX D
HYDROLOGIC AND HYDRAULIC COMPUTATIONS

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject HORTON LAKE DAM S.O. No. _____
APPENDIX D - HYDROLOGIC AND Sheet No. _____ of _____
HYDRAULIC COMPUTATIONS Drawing No. _____
Computed by _____ Checked by _____ Date _____

<u>SUBJECT</u>	<u>PAGE</u>
PREFACE	i
HYDROLOGY AND HYDRAULIC DATA BASE	1
HYDRAULIC DATA	2
DRAINAGE AREA AND CENTROID MAP	3
TOP OF DAM PROFILE AND CROSS SECTION	4
SPILLWAY DISCHARGE RATING	5
100-YEAR DISCHARGE CALCULATION	6

PREFACE

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

The conclusions presented pertain to present conditions, and the effect of future development on the hydrology has not been considered.

HYDROLOGY AND HYDRAULIC ANALYSIS
DATA BASE

NAME OF DAM: HORTON LAKE DAM

100-YEAR STORM = 6.2 INCHES/24 HOURS⁽¹⁾

STATION	1	2	3	4	5
Station Description	HORTON LAKE DAM				
Drainage Area (square miles)	0.58				
Cumulative Drainage Area (square miles)	0.58				
Adjustment of PMF for Drainage Area (%) ⁽¹⁾					
6 Hours					
12 Hours					
24 Hours					
48 Hours					
72 Hours					
Spillway Data					
Crest Length (ft)	39.5				
Freeboard (ft)	1.5				
Discharge Coefficient	2.65				
Exponent	1.5				

MICHAEL BAKER, JR., INC.

THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject

HORTON LAKE DAM

S.O. No. _____

HYDRAULIC DATASheet No. 2 of 7

Drawing No. _____

Computed by

SWT

Checked by

WDLDate 12-2-80STORAGE CALCULATIONSAREA VS. ELEVATION DATA (MEASURED FROM QUADS)

<u>ELEVATION (FT)</u>	<u>SURFACE AREA (ACRES)</u>
1258	33.98
1260	61.61
1280	100.09

NORMAL POOL STORAGE

$$\text{STORAGE VOLUME} = V_{NP} = \frac{1}{3} (A_1 + A_2 + \sqrt{A_1 A_2})$$

 h = ESTIMATED AVERAGE DEPTH = 8.6 FT. A_1 = SURFACE AREA OF NORMAL POOL = 33.98 AC. A_2 = SURFACE AREA OF RESERVOIR BOTTOM = 31.26 AC.(ESTIMATED FROM AVERAGE DEPTH
AND RESERVOIR SIDE SLOPES)

$$\text{NORMAL POOL STORAGE} = V_{NP} = \frac{8.6}{3} (33.98 + 31.26 + \sqrt{(33.98)(31.26)})$$

$$V_{NP} = 280.45 \text{ AC.-FT.}$$

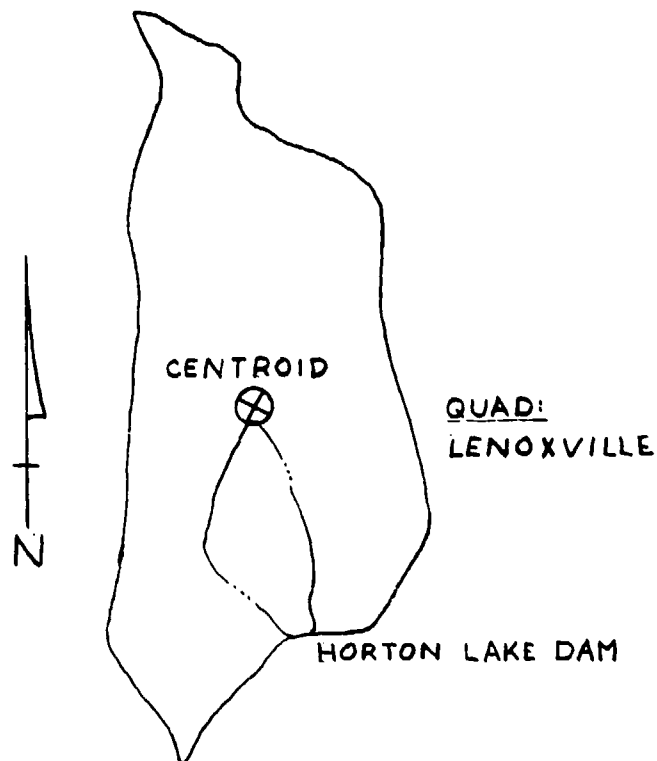
TOP OF DAM STORAGE

$$V = \frac{1}{3} (A_1 + A_2 + \sqrt{A_1 A_2})$$

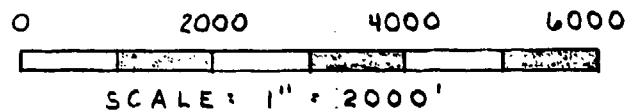
$$V = \frac{10.1}{3} (31.26 + 37.30 + \sqrt{(31.26)(37.30)})$$

$$V = 345.78 \text{ AC.-FT.}$$

$$\text{DRAINAGE AREA} = 0.58 \text{ SQ. MI.}$$



HORTON LAKE:
DRAINAGE AREA AND
CENTROID MAP



Box 280
Beaver, Pa. 15009

Subject HORTON LAKE DAM

S.O. No. 12827-00-APP-10

TOP OF DAM PROFILE

Sheet No. 4 of 7

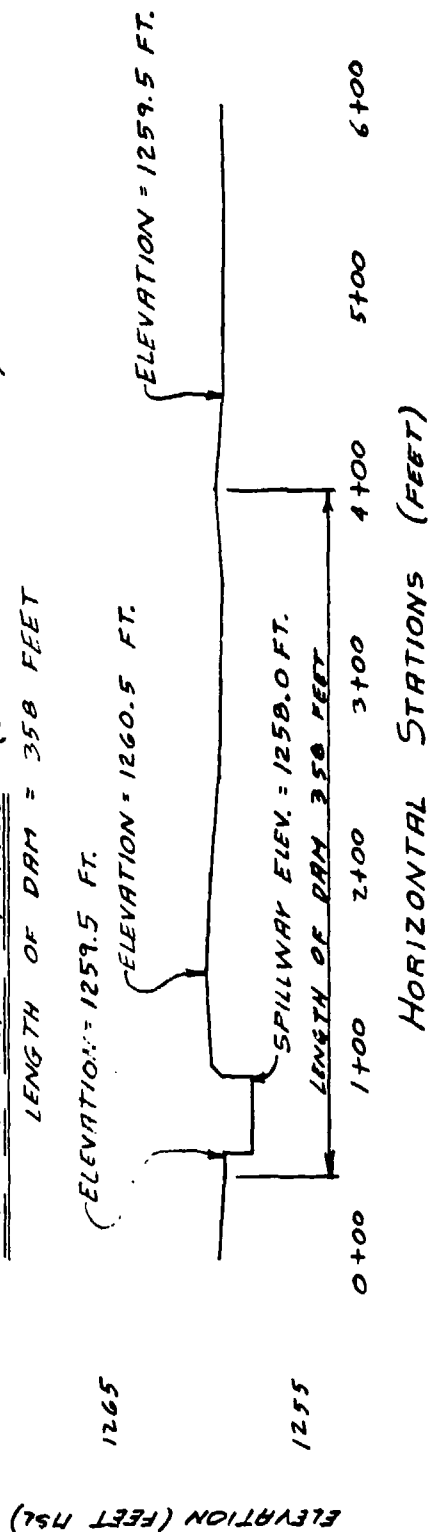
TYPICAL CROSS SECTION

Drawing No. _____

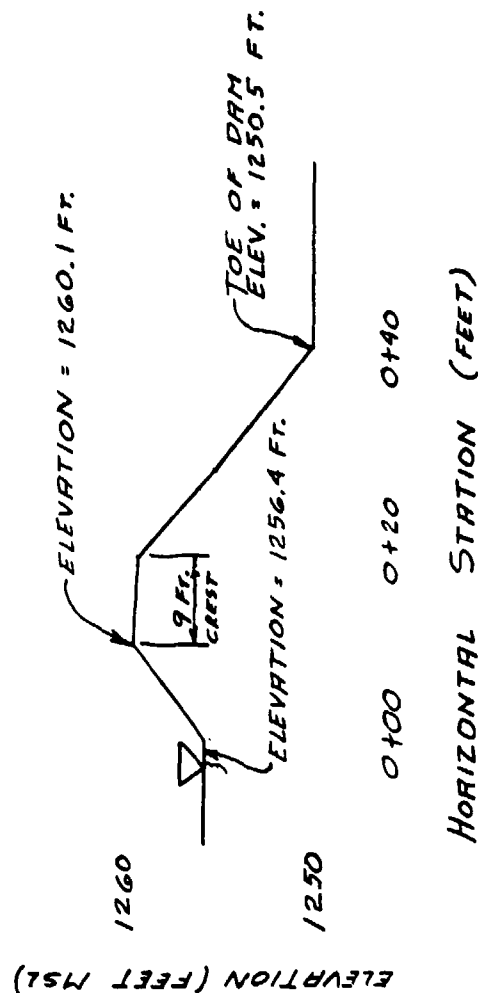
Computed by GWT Checked by _____ Date 11-18-80

TOP OF DAM PROFILE (LOOKING DOWNSTREAM)

LENGTH OF DAM = 358 FEET



TYPICAL CROSS SECTION AT STATION 2+00

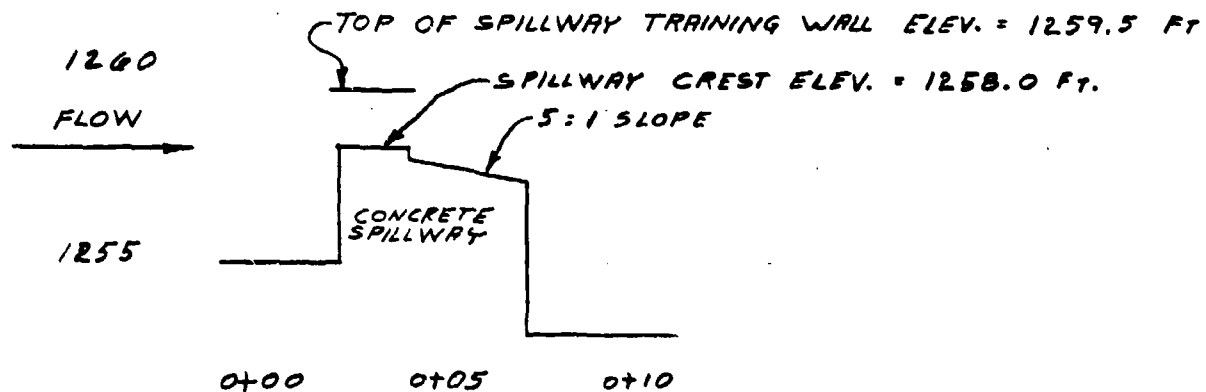


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THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject HOUSTON LAKE DAM S.O. No. 11-927-00-APP-10
SPILLWAY DISCHARGE RATING Sheet No. 5 of 7
Drawing No. _____
Computed by GWT Checked by WDL Date 11-21-00

PROFILE OF SPILLWAY



SPILLWAY RATING CURVE DATA:

THE SPILLWAY IS A CONCRETE, BROAD-CRESTED WEIR.

WEIR LENGTH = 39.5 FT.

WEIR BREADTH = 4.7 FT.

$C = 2.65$ FROM BRATER & KING, HANDBOOK OF HYDRAULICS, P. 5-40

FREEDBOARD IS 1.5 FEET.

$$Q = CLH^{1.5}$$

AT THE MINIMUM TOP OF THE DAM THE SPILLWAY
CAPACITY IS:

$$Q = 2.65 (39.5) (1.5)^{1.5}$$

$$Q = 192.3 \text{ C.F.S.}$$

THE INFLOW TO THE IMPOUNDMENT FOR THE 100-YEAR FLOOD WAS CALCULATED USING MATERIAL FROM "THE HYDROLOGIC STUDY - TROPICAL STORM AGNES" PREPARED BY THE SPECIAL STUDIES BRANCH, PLANNING DIVISION, NORTH ATLANTIC DIVISION, CORPS OF ENGINEERS, IN NEW YORK CITY.

DRAINAGE AREA - 0.58 SQ. MI.

① COMPUTE THE MEAN LOGARITHM.

$$\log(Q_m) = C_m + 0.75 \log A$$

$\log(Q_m)$ = MEAN LOGARITHM OF ANNUAL FLOOD PEAKS

A = DRAINAGE AREA, SQ. MI., = 0.58 SQ. MI.

C_m = MAP COEFFICIENT FOR MEAN LOG OF ANNUAL PEAKS FROM FIG. 21 = 2.16

$$\begin{aligned}\log(Q_m) &= 2.16 + 0.75(\log 0.58) \\ &= 1.983\end{aligned}$$

② COMPUTE STANDARD DEVIATION

$$S = C_s - 0.05(\log A)$$

S = STANDARD DEVIATION OF THE LOGARITHMS OF THE ANNUAL PEAKS.

C_s = MAP COEFFICIENT FOR STANDARD DEVIATION FROM FIG. 22 = 0.349

A = DRAINAGE AREA, SQ. MI., = 0.58 SQ. MI.

$$\begin{aligned}S &= 0.349 - 0.05(\log 0.58) \\ &= 0.352\end{aligned}$$

③ SELECT SKEW COEFFICIENT FROM FIG. 23 = 0.20

④ $\log(Q_{100}) = \log(Q_m) + K(P, g) S$

$K(P, g)$ = STANDARD DEVIATE FOR A GIVEN EXCEEDENCE FREQUENCY PERCENTAGE (P) AND SKEW COEFFICIENT (g) FROM EXHIBIT 39 OF BEARD'S "STATISTICAL METHODS IN HYDROLOGY"

$$\log(Q_{100}) = 1.983 + 2.52(0.352)$$

$$\underline{Q_{100} = 741 \text{ C.F.S.}}$$

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject HORTON LAKE DAM S.O. No. _____
100-YEAR DISCHARGE CALCULATION Sheet No. 7 of 7
Drawing No. _____
Computed by GWT Checked by WDV Date 6/19/81

THE INFLOW TO THE IMPOUNDMENT FOR THE 100-YEAR FLOOD WAS CALCULATED USING MATERIAL FROM "WATER RESOURCES BULLETIN, BULLETIN NO. 13, FLOODS IN PENNSYLVANIA", PREPARED BY THE DEPARTMENT OF ENVIRONMENTAL RESOURCES, COMMONWEALTH OF PENNSYLVANIA.

DRAINAGE BASIN FROM PLATE 2 - MODEL 2
REGRESSION EQUATION FROM TABLE 2

$$Q_T = CA^x$$

$$T = 100 \text{ YEARS}$$

$$C = 564$$

$$A = \text{DRAINAGE AREA, } 0.585 \text{ MI.}$$

$$x = .741$$

$$Q_{100} = 564(0.58)^{.741}$$

$$Q_{100} = 376 \text{ C.F.S.}$$

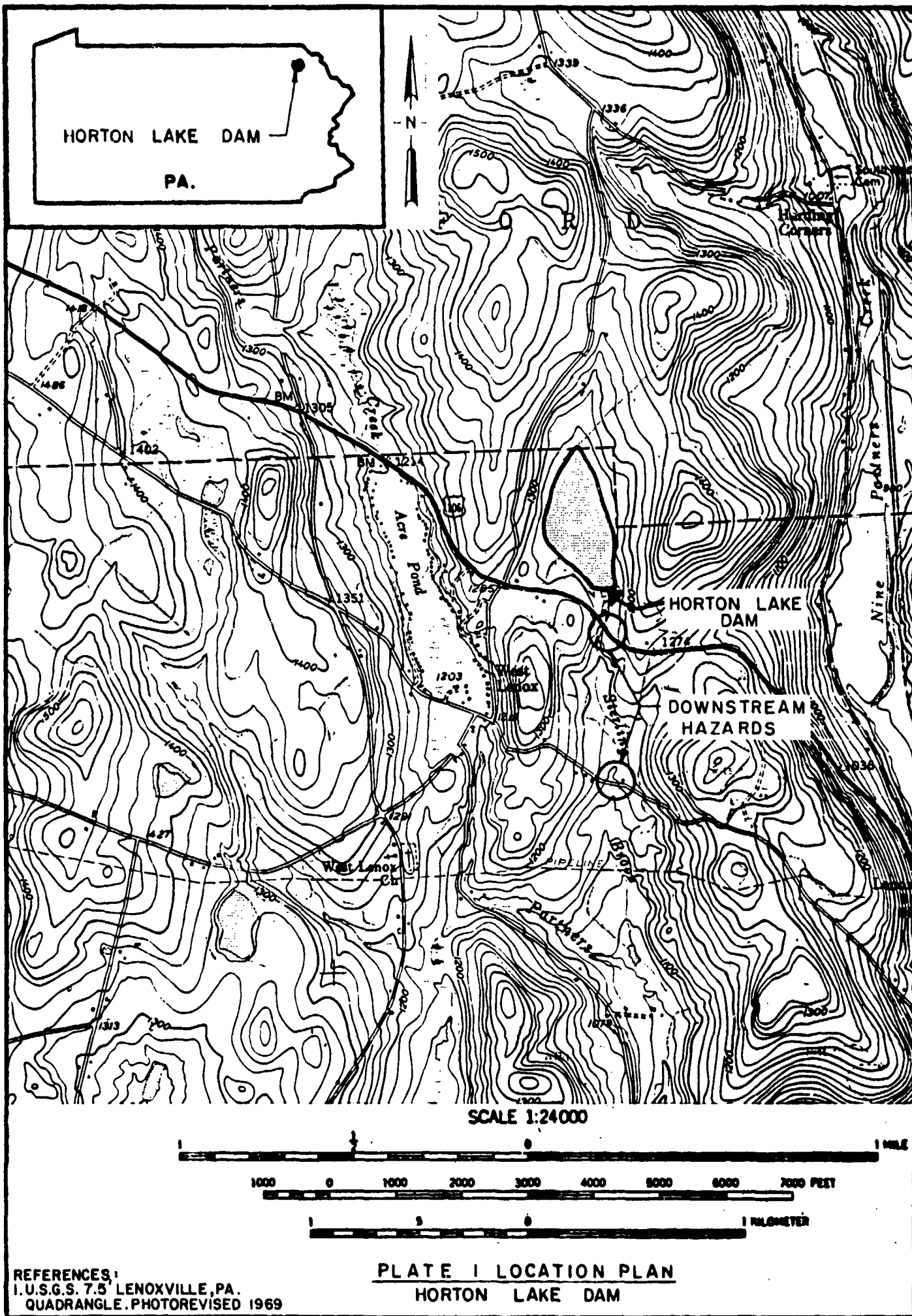
AVERAGING THE INFLOW FROM THIS METHOD AND THE PREVIOUS METHOD GIVES AN INFLOW OF 558 C.F.S. TO THE IMPOUNDMENT.

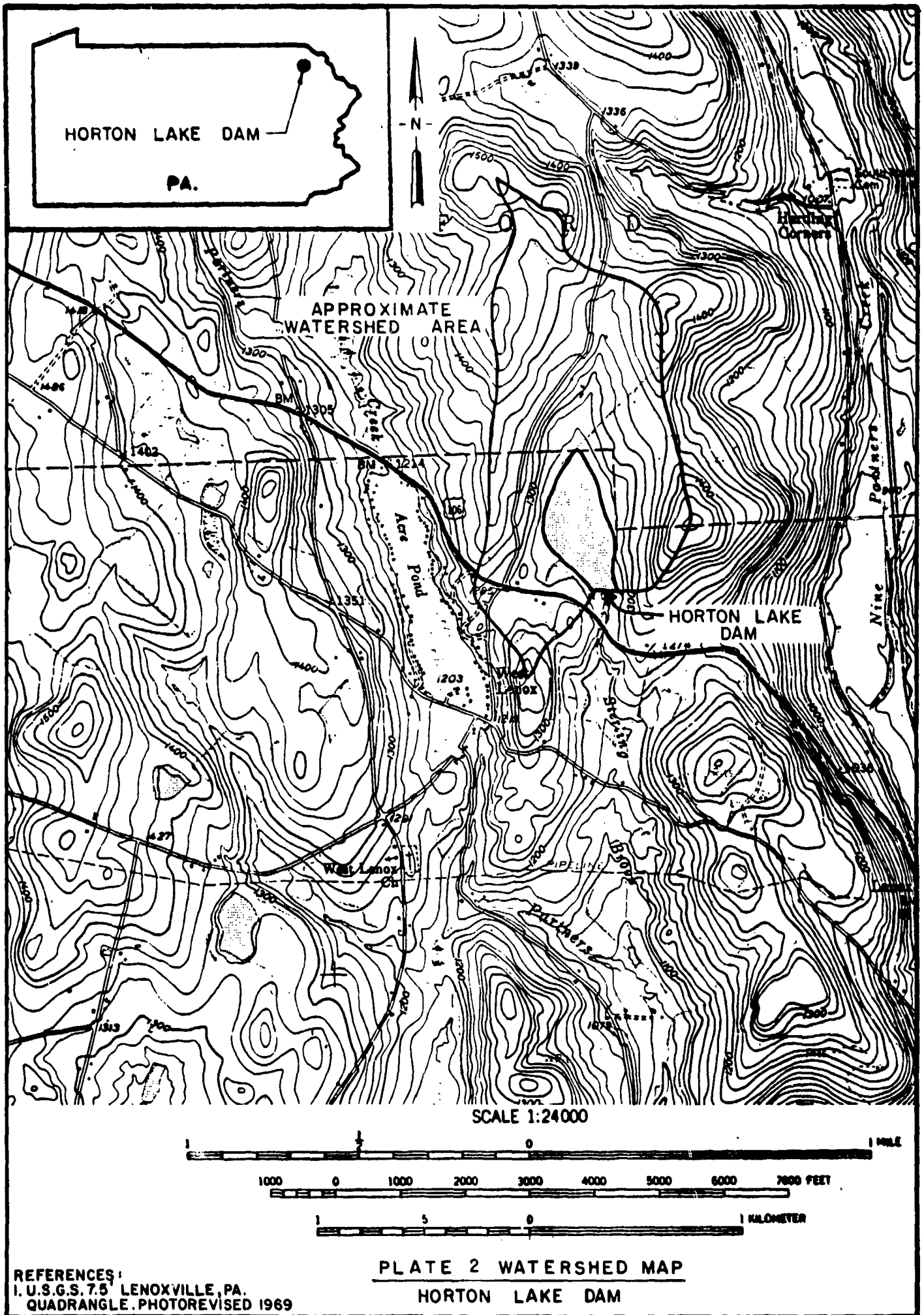
APPENDIX E

PLATES

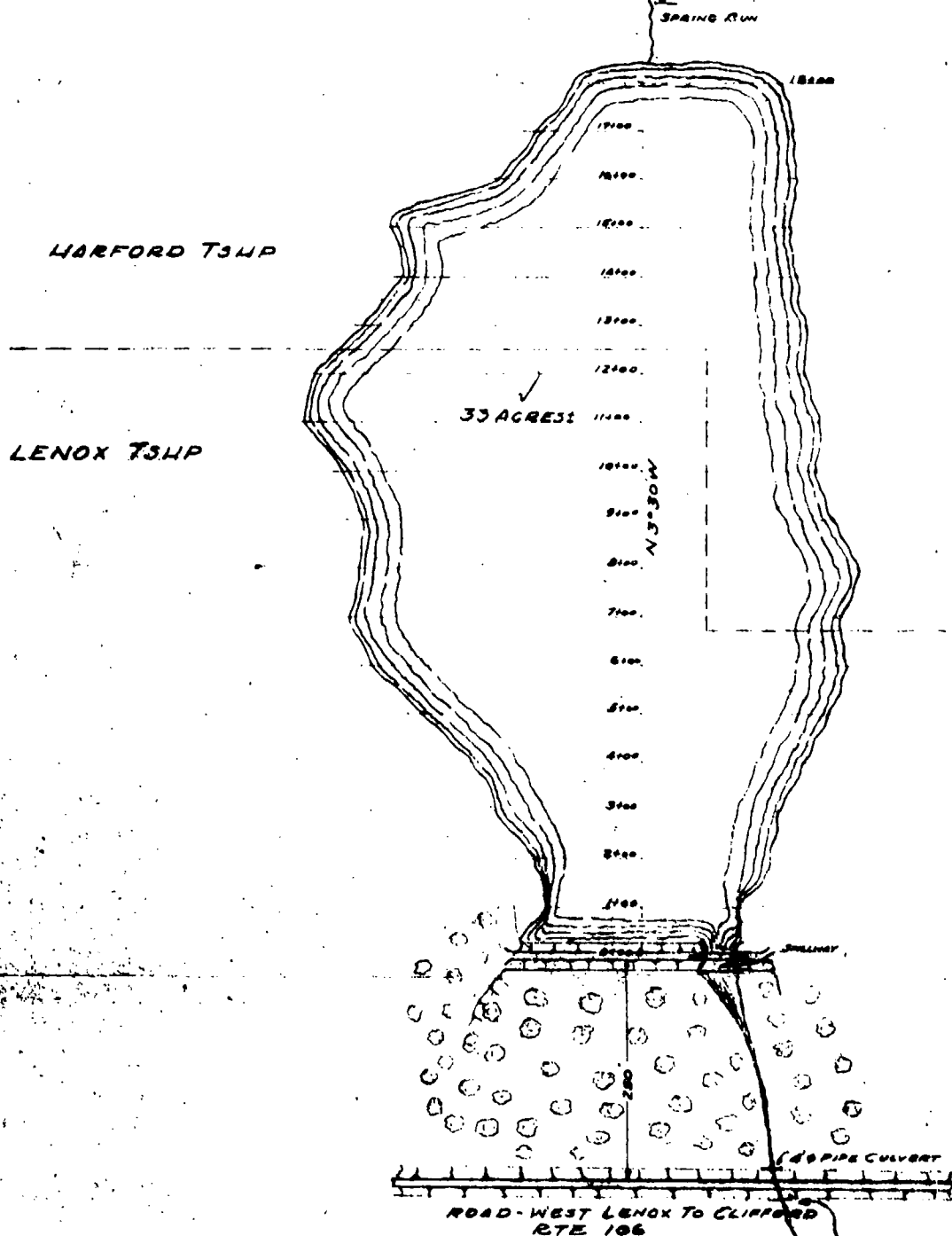
CONTENTS

- Plate 1 - Location Plan
- Plate 2 - Watershed Map
- Plate 3 - General Location Map and Plan of Reservoir (1955)
- Plate 4 - Plan and Section of Spillway (1955)
- Plate 5 - Profile and Section Through Embankment, Section
Through Outlet Pipe (1955)
- Plate 6 - Cross Sections Through Reservoir (1955)





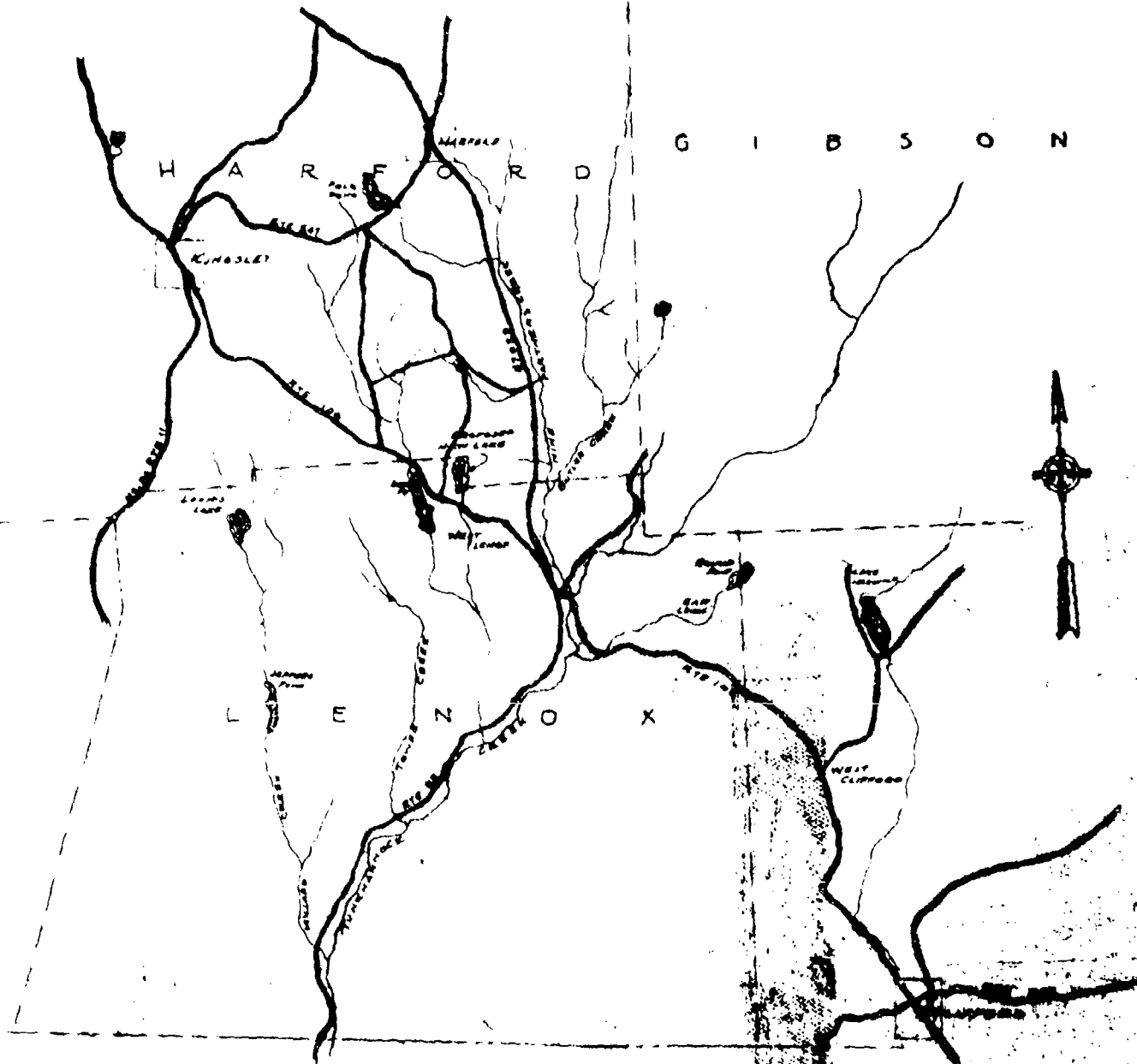
NOTE: THERE IS NO CREEK, OR
VISIBLE DRY CREEK BED AT THE SOURCE
OF THIS POND. ENTIRE WATER SUPPLY
IS DERIVED FROM SPRING AT HEAD OF
POND. SURFACE DRAINAGE AREA 1.5



SCALE: 1" = 200 FT.

NOTE: THIS PIPE CULVERT, OF
SUFFICIENT AREA TO HANDLE
RUN-OFF OF DRAINAGE AREA
AS WAS EVIDENCED BY ABR
RUNOFF IN 1962 AND 1963,
WITHOUT OVERLOADING AND

SHEET 24
 AT THE SOURCE
 WATER SUPPLY
 IN AT LEAST OF
 SHEET AREA 15.50 MI.



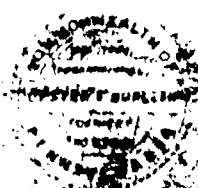
SCALE
 0 1 2 3 4 5 6 7 8 9 10

PORTION OF
 SUSQUEHANNA CO.

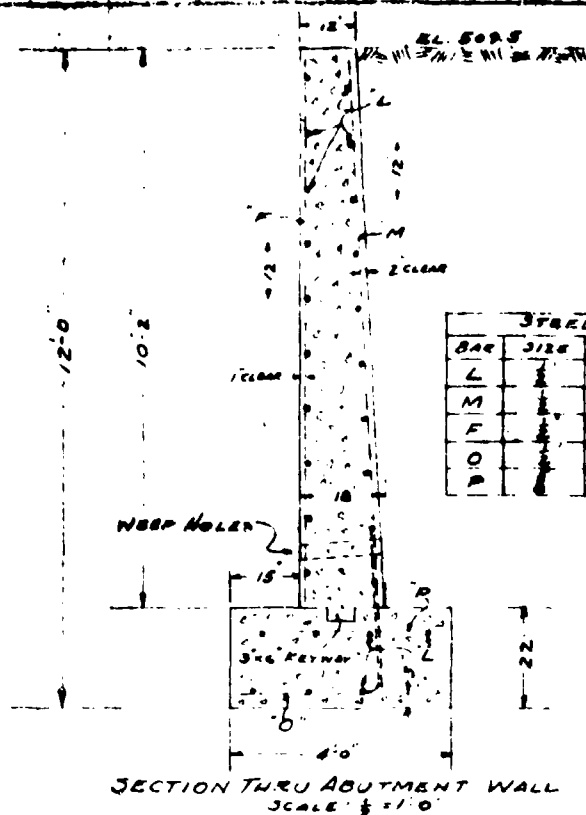
SHOWING LOCATION OF PROPOSED LAKE
 TO BE CONSTRUCTED FOR HARRY HORTON CLIFFORD, JR.

PIPE CULVERT, 48 DIA IS
 IT AREA TO HANDLE ALL
 DRAINAGE AREA INVOLVED
 DENCED BY AQUIVITY TO CARRY
 1942 AND 1982 (FLASH FLOODS)
 RELOADING AND CONSEQUENT ROAD WASH

PLATE-3



PROPOSED
 NEW DAM AND SPILLWAY
 HARRY HORTON CLIFFORD, JR.
 SUSQUEHANNA COUNTY, NEW YORK



STEEL REINFORCEMENT			
BAR	SIZE	LENGTH	SPACING
L	1	—	12
M	1	11'-6"	16
F	1	3'-10"	12
O	1	5'-6"	24
P	1	3'-6"	16

SECTION THRU ABUTMENT WALL
SCALE: $\frac{1}{8} = 1' 0"$

6-21	FOOTING
0-21	FOUNDATION

20.

40'0

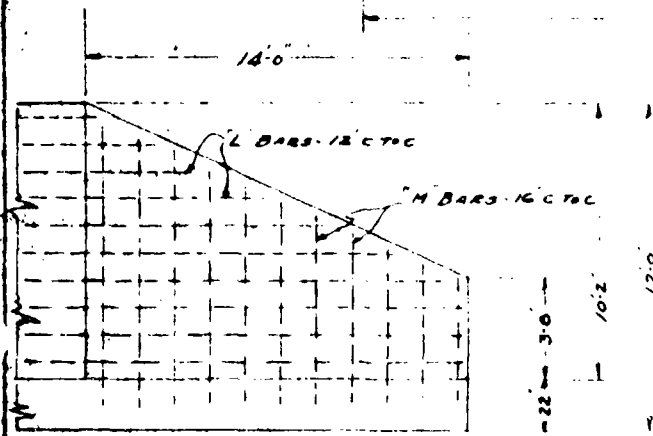
50' 9'

PLAN
4-10

$\frac{1}{2}$ ϕ BARS 11 LONG 18 CIRC

REINFORCING OF FOOTING
SAME AS FOR ABUTMENT EXCEPT
NO "O" BARS

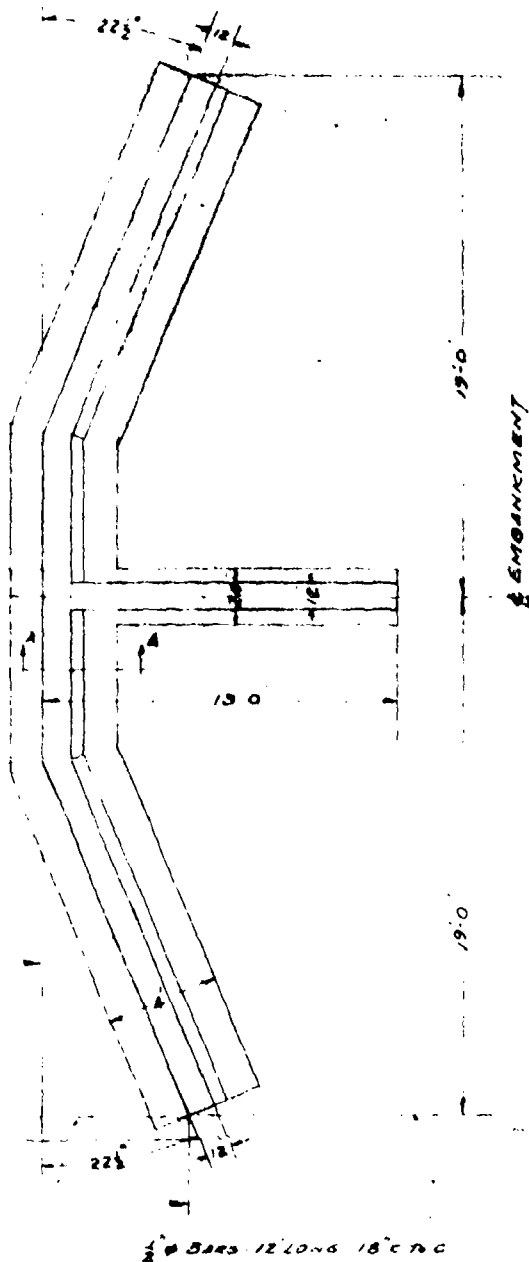
— SPILLWAY



STEEL REINFORCEMENT
- WING WALL -
4' 3" 0"

EMBANKMENT	SPACING
12	6
16	12
24	24
36	36

FOOTING 12'-9"
ABUTMENT 12'-0"



EMBANKMENT

EMBANKMENT FILL SHALL BE INITIAL
GRADE 1 FT ABOVE FINISHED TOP OF EMBANKMENT TO ALLOW
FOR SETTLEMENT

4 WEIR HOLES 4' C/C
C - EACH WING

10'-2"

LARGER STONE HAND PLACED TO
A DEPTH OF 24" IN DISCHARGE
CHANNEL

NOTE: ALL EMBANKMENT FILL
THIS STRUCTURE SHALL BE
PLACED TO A DEPTH OF 1 FT
ABOVE FINISHED TOP OF
EMBANKMENT TO ALLOW FOR
SETTLEMENT

SECTION A-A

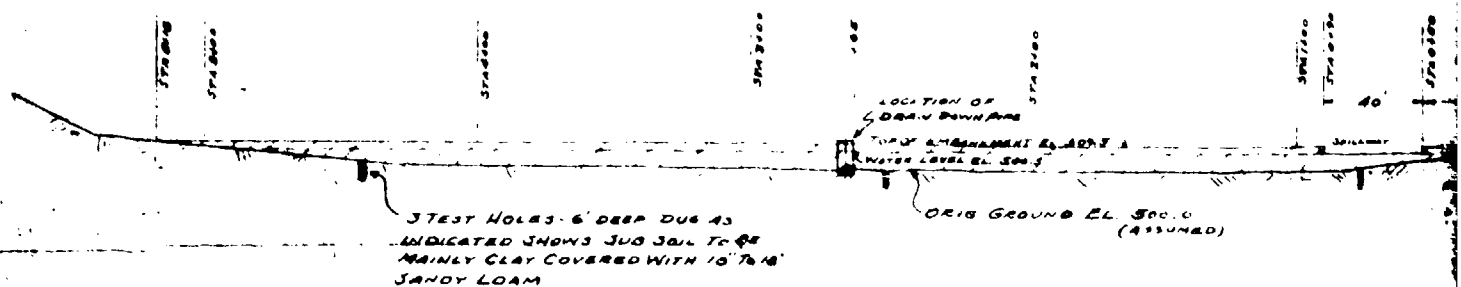
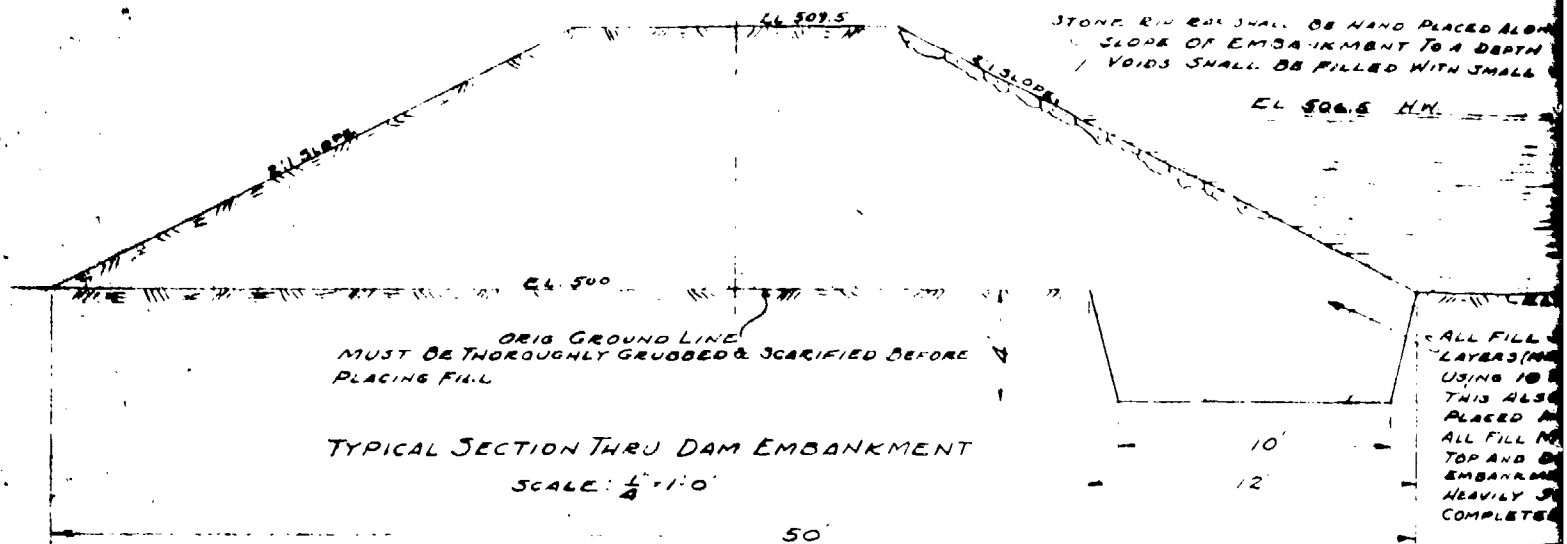
PLAT

PROPOSED NEW DA
SPILLWAY FOR HARRY A
CLIFFORD, JACOB HANNA
JUNE 1938
L. K. BROWN, JR.

WAY DETAILS

REINFORCEMENT OF CUT-OFF WALL

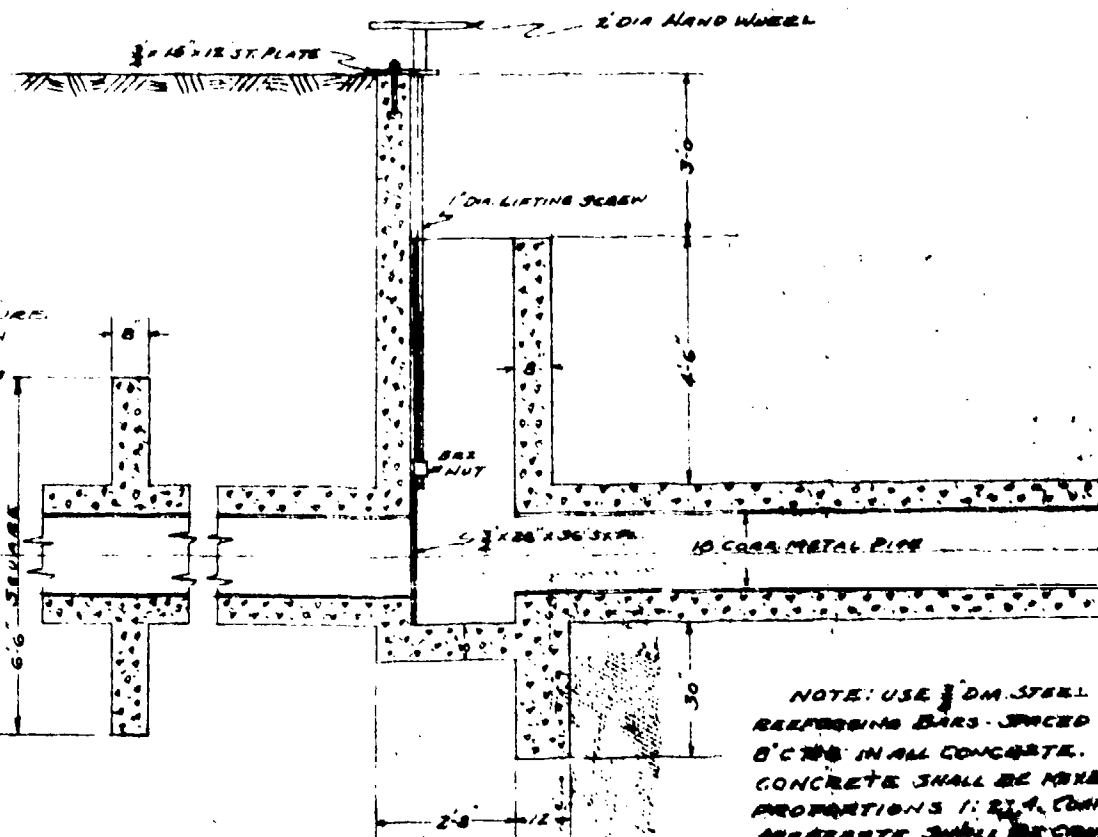
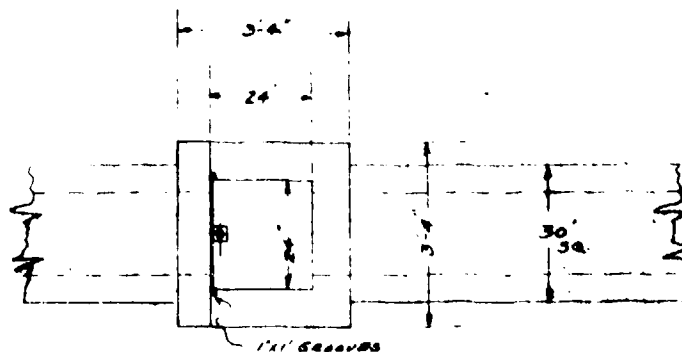
2



LONGITUDINAL SECTION THRU EMBANKMENT
SCALE: 1" = 40 FT

AND PLACED ALONG ENTIRE UPSTREAM
BENT TO A DEPTH OF 12 TO 18" ALL
BED WITH SMALL STONES

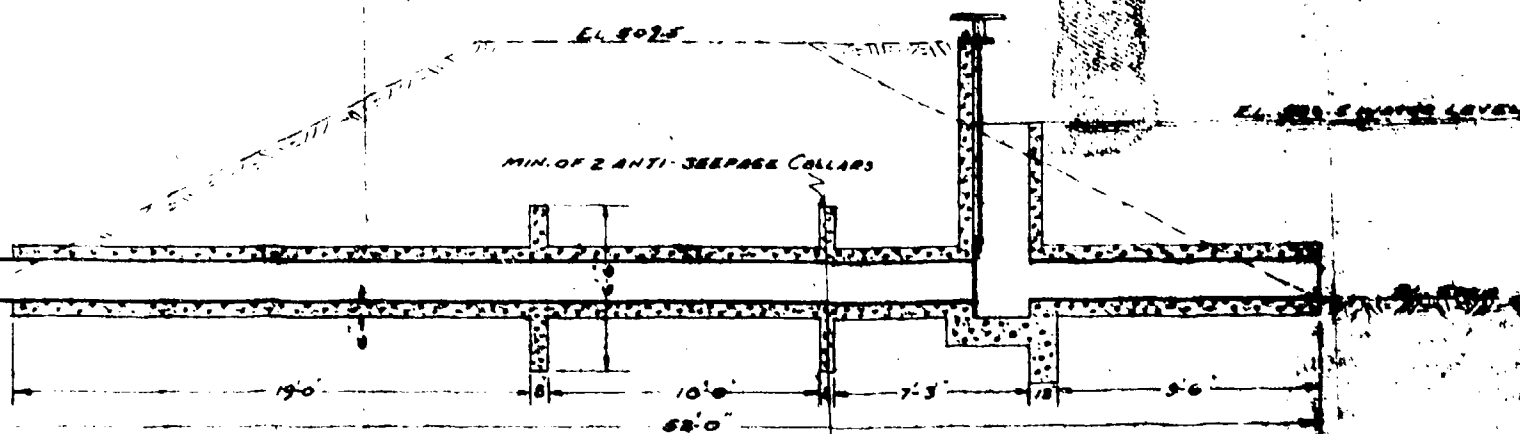
M.H.



ALL FILL SHALL BE PLACED IN 6" LAYERS (MAX) AND THOROUGHLY ROLLED USING 10 TON ROLLER. THIS ALSO APPLIES TO MATERIAL PLACED IN CUT-OFF TRENCH. ALL FILL MTL SHALL BE SAND-CLAY MIXTURE. TOP AND DOWNSTREAM SLOPE OF ALL EARTH EMBANKMENTS SHALL BE FERTILIZED AND HEAVILY SEEDED WITH GRASS, AS SOON AS COMPLETED. STRAW MULCH SHALL BE USED

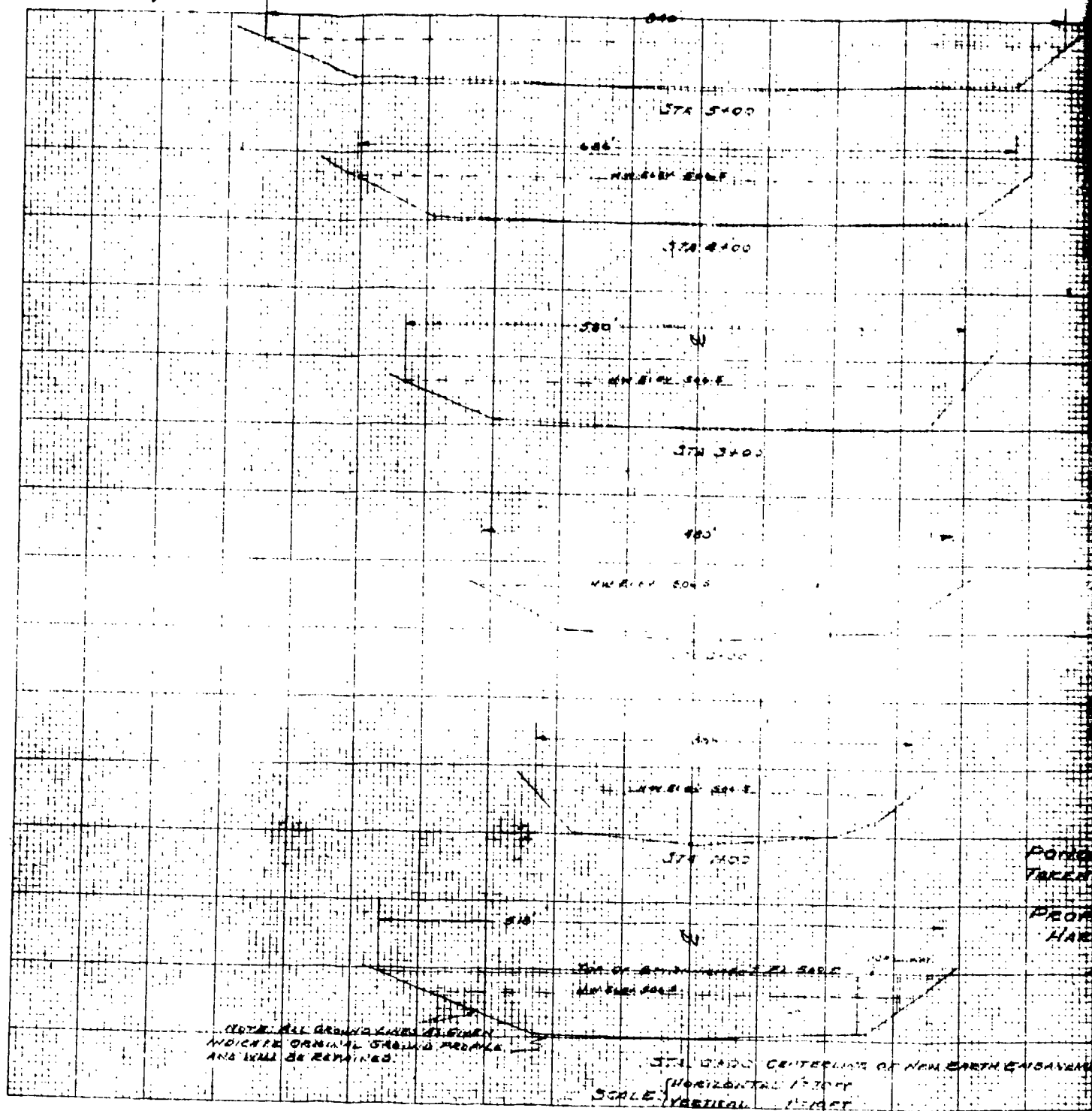
NOTE: USE 3/8" DIA. STEEL REINFORCING BARS SPACED 8" O.C. IN ALL CONCRETE. CONCRETE SHALL BE MIXED PROPORTIONS 1:2 1/4:4. COARSE AGGREGATE SHALL BE CRUSHED STONE OR GRAVEL.

DRAW DOWN DETAILS
SCALE: 1/4" = 1'-0"



SECTION THROUGH DRAW-DOWN PIPE
SCALE: 1/4" = 1'-0"

PLATE - 5



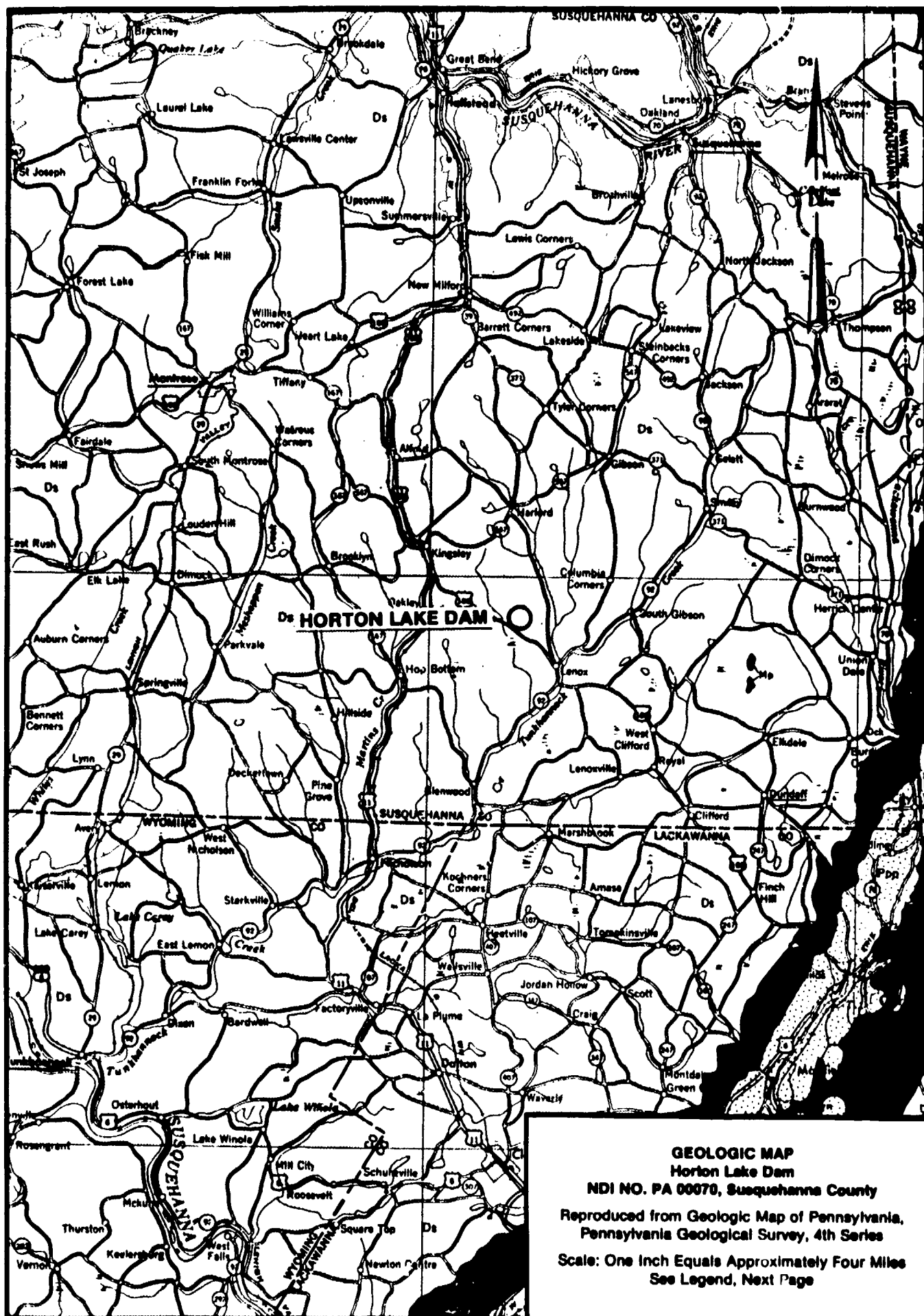
APPENDIX F
REGIONAL GEOLOGY

Horton Lake Dam
NDI No. PA 00070, PennDER No. 58-124

REGIONAL GEOLOGY

Horton Lake Dam is located in the Glaciated Low Plateaus section of the Appalachian Plateaus physiographic province. The area has been glaciated at least three times and is presently covered with Wisconsin stage glacial deposits. The land drains to the south via Tunkhannock Creek and shows a maximum relief of approximately 500 feet. According to the Soil Conservation Service's Soil Survey for Susquehanna County, surface soils in the vicinity of the dam consist primarily of slightly flaggy, silt loams of the Morris-Wellsboro-Volusia association. No test borings were available for review; thus, the thickness of this overburden is difficult to ascertain.





Geologic references indicate that the bedrock in the vicinity of the dam consists of members of the Catskill Formation in the Susquehanna Group. The Catskill is composed primarily of red and gray shales and sandstones of Upper Devonian age. The formation may also contain scattered, thin streaks of coal and scattered fish remains. The strata in the vicinity of the dam was deposited in a delta front type of environment and remain essentially horizontal after the Appalachian Uplift. However, southeast of Tunkhannock Creek the strata starts to curve up into a large anticline whose axis strikes northeast. This suggests the possibility of artesian conditions beneath the dam. Flowing wells have been documented to the northeast of the dam location.






GEOLOGY MAP LEGEND

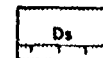
DEVONIAN UPPER

WESTERN PENNSYLVANIA

-  **Oswayo Formation**
Greenish gray to gray shales, siltstones and sandstones becoming increasingly shaly westward; considered equivalent to type Oswayo, Riceville Formation Dr in Erie and Crawford Counties; probably not distinguishable north of Corry.
-  **Cattaraugus Formation**
Red, gray and brown shale and sandstone with the proportion of red decreasing westward; includes Venango sands of drillers and Salamanca sandstone and conglomerate; some limestone in Crawford and Erie counties.
-  **Conneaut Group**
Alternating gray, brown, greenish and purplish shales and siltstones; includes "pink rock" of drillers and "Chemung" and "Givard" Formations of northwestern Pennsylvania.
-  **Canadaway Formation**
Alternating brown shales and sandstones; includes "Portage" Formation of northwestern Pennsylvania.

CENTRAL AND EASTERN PENNSYLVANIA

-  **Oswayo Formation**
Brownish and greenish gray, fine and medium grained sandstones with some shales and scattered calcareous lenses; includes red shales which become more numerous eastward. Relation to type Oswayo not proved.
-  **Catskill Formation**
Chiefly red to brownish shales and sandstones; includes gray and greenish sandstone tongues named Elk Mountain, Honesdale, Shohola, and Delaware River in the east.
-  **Marine beds**
Gray to olive brown shales, graywackes, and sandstones; contains "Chemung" beds and "Portage" beds including Burket, Brallier, Harrell, and Trimmers Rock; Tully Limestone at base.








Susquehanna Group

Barbed line is "Chemung-Catskill" contact of Second Pennsylvania Survey County reports; barbs on "Chemung" side of line.

MIDDLE AND LOWER



Hamilton Group

-  **Mahantango Formation**
Brown to olive shale with interbedded sandstones which are dominant in places (Montebello); highly fossiliferous in upper part; contains "Centerfield coral bed" in eastern Pennsylvania.
-  **Marcellus Formation**
Black, fissile, carbonaceous shale with thick, brown sandstone (Turkey Ridge) in parts of central Pennsylvania.
-  **Onondaga Formation**
Greenish blue, thin bedded shale and dark blue to black, medium bedded limestone with shale predominant in most places; includes Selinagrope Limestone and Needmore Shale in central Pennsylvania and Buttermilk Falls Limestone and Keopus Shale in easternmost Pennsylvania; in Lehigh Gap area includes Palmerton Sandstone and Bowmanstown Chert.
-  **Oriskany Formation**
White to brown, fine to coarse grained, partly calcareous, locally conglomeratic, fossiliferous sandstone (Ridgeley) at the top; dark gray, cherty limestone with some interbedded shales and sandstones below (Shriver).
-  **Helderberg Formation**
Dark gray, calcareous, thin bedded shale (Mandata) at the top, equivalent to Port Even Shale and Becraft Limestone in the east; dark gray, cherty, thin bedded, fossiliferous limestone (New Scotland) with some local sandstones in the middle; and, at the base dark gray, medium to thick bedded, crystalline limestone (Cheymunal, mudy and shaly in places with some chert nodules).

